1.2.3 What ecological effects are associated with acid deposition?

Increased acid levels damage soils, lakes, and streams, rendering some waterbodies unfit for certain fish and wildlife species. Indirect effects of acid deposition are also responsible for damage to forest ecosystems (see Chapter 5, Ecological Condition). Acidic ions in the soil displace calcium and other nutrients from plant roots, inhibiting growth. Acidic deposition can also mobilize toxic amounts of aluminum, increasing its availability for uptake by plants and by fish and other aquatic life (EPA, OAR, November 2002).

The nitrogen in acid rain adds to the total loading of nitrogen in waterbodies. As coastal ecosystems become overly rich in nitrogen, conditions favor more frequent and more severe emergence of algal blooms, which deplete oxygen, harming fish and reducing plant and animal diversity (see Chapter 2, Purer Water).

A recent report assessing deposition-related changes in surface water chemistry in the northern and eastern U.S. found that the Clean Air Act has resulted in a large and widespread decrease in the deposition of sulfur by approximately 40 percent in the 1990s. In the same period, surface water sulfate concentrations declined in all regions except the Ridge and Blue Ridge provinces (Virginia). Acid neutralizing capacity (ANC), a key indicator of recovery, increased in three of the regions (Adirondacks, Northern Appalachian Plateau and Upper Midwest) and was unchanged in the New England and the Ridge/Blue Ridge region. Modest increases in ANC have reduced the number of acidic lakes and stream segments in some regions:

- In the Adirondacks, 8.1 percent of lakes (150 lakes) were acidic in 2000. In the early 1990s, 13 percent (240 lakes) were acidic.
- In the Upper Midwest, an estimated 80 of 250 lakes that were acidic in the mid-1980s are no longer acidic.
- In the Northern Appalachian Plateau region in 2000, there were an estimated 3,393 kilometers (2,104 miles) of acidic streams in the region, or 7.9 percent of the total population; this compares to 5,014 kilometers (3,109 miles) of acidic streams (12 percent) in 1993-94.
- There was no evidence of recovery in New England, or in the Ridge and Blue Ridge Provinces; the latter region is not expected to recover immediately, due to the nature of forest soils in the province.
- In the three regions showing recovery, approximately one-third of formerly acidic surface waters are no longer acidic, although still subject to episodes of acidification.
- Nitrogen deposition levels changed little between 1989 and 2001, and surface water nitrate concentrations are largely unchanged as well. Nitrogen deposition remains a concern, because future increases in surface water nitrate concentrations could retard surface water recovery (EPA, ORD, January 2003).

No specific indicators have been identified at this time to address the ecological effects associated with acid deposition.

1.3 Indoor Air Quality

People in the U.S. spend 90 percent of their time indoors, and indoor air pollutant levels may exceed those allowable outside. Radon and environmental tobacco smoke (ETS) are the two indoor air pollutants of greatest concern from a health perspective (EPA, ORD, December 1992; NRC, 1988).

Although methods to monitor and measure indoor air quality (IAQ) exist, there is no practical way to assess the general quality of indoor air nationwide. There are millions of residences, thousands of workplaces, and more than a hundred thousand schools in the U.S., and representative samples are not practical because of cost and access issues. This section, therefore, presents indoor air quality data from limited studies, not from ongoing monitoring efforts.

This section addresses the following questions:

- What is the quality of the air in buildings in the United States? (Section 1.3.1)
- What contributes to indoor air pollution? (Section 1.3.2)
- What human health effects are associated with indoor air pollution? (Section 1.3.3)

1.3.1 What is the quality of the air in buildings in the United States?

Indicators

U.S. homes above EPA's radon action levels
Percentage of homes where young children are exposed to environmental tobacco smoke

While it is difficult to make general statements about the quality of indoor air nationwide, two studies–the National Residential Radon Survey and an analysis of ETS exposure based on data from the National Health Interview Survey–offer important insights. These studies provide data about residential levels of radon and ETS, presented in the description of two indicators on the following pages.

In addition, several studies have attempted to characterize environmental issues inside office buildings and schools. The Building Assessment Survey and Evaluation (BASE) study, conducted from 1994 to 1998, is a study of office IAQ. The study was designed with input from more than 40 national IAQ experts and reviewed by the EPA Science Advisory Board. The consensus of these national experts was that a sample of 100 to 200 office buildings would be sufficient to characterize the central tendency of IAQ in office buildings nationwide.

Limited information about IAQ in schools is available from a 1999 survey of about 900 public schools by the National Center for Education Statistics. This survey addressed concerns related to environmental conditions, defined as lighting, heating, ventilation, IAQ, acoustics or noise control, and physical security of buildings. In all, 43 percent of schools responded that at least one environmental condition was unsatisfactory. Ventilation was the most often cited environmental issue of concern (DOE, NCES, 2000).

In addition to the indoor pollutants discussed above, pesticides also may pose IAQ concerns. Approximately three-quarters of U.S. households use at least one pesticide product indoors during the course of a year. Products used most often are insecticides and disinfectants. The EPA Nonoccupational Pesticide Exposure Study (NOPES), published in 1990, assessed exposure to airborne pesticides in Jacksonville, Florida, and in Springfield and Chicopee, Massachusetts. Indoor sources accounted for 90 percent or more of the total airborne exposure to most of these pesticides. NOPES found that tested households had at least 5 pesticides in indoor air, at levels often 10 times greater than levels measured in outdoor air (EPA, AREAL, January 1990). Some of the pesticides had been banned or otherwise regulated by EPA (e.g., aldrin, dieldrin, heptachlor, and chlordane), but continued to be found in the homes. Since these pesticides previously were widely used to prevent termites, they are believed to have entered the homes via diffusion of soil gas into basements, similar to the way radon enters homes. Another pesticide, DDT, banned for nearly 20 years, was found in house dust in five out of eight homes (EPA, AREAL, January 1990). Later studies, including measurements in soil just outside the home, suggested that DDT and other long-lasting pesticides can be tracked in from soil clinging to shoes.

No comprehensive nationwide information is available on the amount of pesticides used in the nation's 11,000 public schools. The federal government has not collected such data, and only one state, Louisiana, requires its school districts to specifically report the amount of pesticides used (GAO, 1999).

This report uses two indicators, discussed below, to address the question, "What is the quality of air in the buildings in the United States?":

- U.S. homes above EPA radon action levels.
- Percentage of homes where young children are exposed to ETS.

Indicator U.S. homes above EPA's radon action levels - Category 2

Naturally occurring radon gas is formed by the decay of uranium in rock, soil, and water. Radon enters a home by moving up from rock and soil and into the building through cracks or other holes in the foundation.

The amount of radon gas in the air is measured in picocuries per liter of air or pCi/L. EPA has set a recommended "action level" of four pCi/L for homes and schools to reduce the risk of lung cancer.

What the Data Show

A 1991 representative survey of all housing units in the United States estimated that six percent of U.S. homes (5.8 million in 1990) had an annual average radon level of more than four picocuries per liter (pCi/L) in indoor air. Also, about 56 percent of Americans' exposure to radon occurs in homes with two pCi/L or more. Single-family detached homes were four times more likely to require mitigation than multi-family homes. The survey's findings were used in constructing EPA's estimate of U.S. lung cancer risks from radon, in setting the four pCi/L action level, and in crafting testing and mitigation guidance for the American public (EPA, OAR, October 1992).

Indicator Data Gaps and Limitations

The study is several years old and may not reflect changes brought about as a result of significant EPA radon public education campaigns since that time. Since the mid-1980s, about 18 million homes have been tested for radon and about 700,000 of them have been mitigated. In addition, since 1990 approximately one million new homes have been built with radon-resistant features.

Data Source

The data source for this indicator was *National Radon Residential Survey: Summary Report EPA*, 1992. (See Appendix B, page B-7, for more information.)

Indicator: Percentage of homes where young children are exposed to environmental tobacco smoke – Category 2

Environmental tobacco smoke (ETS)—smoke emitted from the burning end of a cigarette, pipe, or cigar, and smoke exhaled by a smoker—is a complex mix of more than 4,000 chemical compounds, containing many known or suspected carcinogens and toxic agents, including particles, carbon monoxide, and formaldehyde.

What the Data Show

The National Center for Health Statistics has conducted a major nationwide survey, known as the National Health Interview Survey, continuously since 1957. The survey estimated that in 1998, young children were exposed to ETS in 20 percent of homes in the U.S.—down from approximately 39 percent in 1986. About 43,000 households and 106,000 people participated in the survey (DHHS, NCHS, 2001).

Indicator Data Gaps and Limitations

The estimate is not based on a specific question about children's exposure to ETS, but rather is calculated based on the number of houses with smokers and with children.

Data Source

The data source for this indicator was *Healthy People 2000 Final Review,* Department of Health and Human Services, National Center for Health Statistics, 2001. (See Appendix B, page B-7, for more information.)

1.3.2 What contributes to indoor air pollution?

Indoor air pollutants come from a wide array of sources. In considering the potential impact of these sources on indoor air quality, it is vital to recognize the exchange between indoor and outdoor air. Exchange rates vary considerably from building to building, from one part of the country to another, and by seasons. Tight building construction improves energy efficiency but reduces indoor-outdoor air exchange and may contribute to indoor air pollution.

Among the sources of indoor air pollution are:

- Combustion of fuel used for heating and cooking, including oil, gas, kerosene, coal, and wood.
- Environmental tobacco smoke.
- Some adhesives, paints, and coatings (building materials).
- Furniture made of certain pressed wood products.
- Deteriorated, asbestos-containing insulation.
- Some products for household cleaning and maintenance, personal care, or hobbies.
- Inadequate maintenance of central heating and cooling systems.
- Radon, pesticides, and outdoor air pollution.
- Biological sources, including animal dander, cockroaches, dust mites, molds, and fungi.

1.3.3 What human health effects are associated with indoor air pollution?

In general, indoor air pollution can cause headaches, tiredness, dizziness, nausea, and throat irritation. More serious effects include cancer and exacerbation of chronic respiratory diseases, such as asthma. The most sensitive and vulnerable population groups—the elderly, the young, and the infirm—tend to spend the most time indoors; therefore, they may face higher than usual exposures.

Radon is estimated to be the second leading cause of lung cancer in the U.S. In an EPA-sponsored study, the National Research Council (NRC) found between 15,000 and 22,000 radon-related lung cancer deaths annually in the U.S. (NRC, 1998).

Environmental tobacco smoke causes eye, nose, and throat irritation, and is a carcinogen. Children exposed to ETS are at increased risk for respiratory problems and experience increased episodes of asthma (Mannino, et al., 2001). In studies of lifelong nonsmoking women, there was a 24 percent excess risk of lung cancer as a result of ETS exposures from a spouse's smoking (Hackshaw, 1998).

Asthma, particularly in children, is associated with poor indoor air quality. Dust mite proliferation in moist indoor environments can lead to asthma attacks. Other allergens and irritants such as animal dander, ETS, pesticide sprays, cockroach particles, and chemical fumes from household products have also been shown to increase asthma attack rates (IOM, 2000).

Fungal spores from mold growth in moist areas in homes have been associated with health effects in occupants, including allergies and asthma (IOM, 1993). Headaches, respiratory distress, and cardiovascular effects are also associated with exposure to molds.

No specific indicators have been identified at this time to address the human health effects associated with indoor air pollution.

1.4 Stratospheric Ozone

Although ozone is a harmful pollutant at ground level, it plays a valuable role in the stratosphere–the part of the atmosphere at an altitude of 10 to 30 km–by filtering harmful radiation from the sun. The sun's radiation bathes the Earth in ultraviolet (UV) wavelengths of 150 to 400 nanometers (nm). Ultraviolet radiation in the band between 280 and 320 nm, known as UV-B, is harmful to most organisms.

About 90 percent of the planet's ozone at a given time is in a thin layer of the lower stratosphere called the ozone layer, which also includes other gases. Ozone is constantly being created and destroyed by UV radiation. About 95 to 99 percent of UV-B radiation that reaches the Earth's surface is absorbed by ozone and oxygen in the ozone layer (NASA, 2002).

The ozone layer varies in space and time and is highly susceptible to changes in atmospheric chemical reactions by which it is created and destroyed. Scientists in the 1970s and 1980s discovered that human-caused changes to the composition of the atmosphere were leading to depletion of stratospheric ozone (NASA, 2002). They initially identified chlorofluorocarbons (CFCs) as being particularly significant stratospheric ozone depleters. Scientists subsequently identified additional human-produced ozone-depleting substances (ODSs).

This section poses four questions about stratospheric ozone:

- What are the trends in the Earth's ozone layer? (Section 1.4.1)
- What is causing changes to the ozone layer? (Section 1.4.2)
- What human health effects are associated with stratospheric ozone depletion? (Section 1.4.3)
- What ecological effects are associated with stratospheric ozone depletion? (Section 1.4.4)

1.4.1 What are the trends in the Earth's ozone layer?

Indicators

Ozone levels over North America

The most recent authoritative assessment of the Earth's stratospheric ozone is the *Scientific Assessment of Ozone Depletion: 2002* (Scientific Assessment Panel, 2003), conducted under the auspices of the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). The study found an average decrease of about 6 percent in average ozone concentrations between 35 and 60 degrees South for the period 1997 to 2001, compared with pre-1980 average values. It also found an